Customizable Tool for Complex Systems Visualization

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ABSTRACT

The last generation of tools used for complex systems monitoring are based on 3D visualization. No doubt, they have allowed to make several improvements but the large amount of dynamical information gathered from heterogeneous environments and the growth of management protocols still make monitoring tasks an interesting research topic. A set of techniques is presented here to manage any complex system by offering a customizable 3D visualization tool associated with a standard information model, which enables to manage environments, devices and applications uniformly regardless of industry and vendor. The aim of this work is to allow tools for any complex system management and monitoring, but we have chosen clusters/grids of networked computers as a first domain of study.

Keywords
3D Visualization, Computer network management, Common Information Model

1. INTRODUCTION

Almost all complex systems are built with heterogeneous environments. The main problem of such systems is to find ways and methods to achieve efficiently the management and monitoring tasks because each environment proposes its own management protocol and thus its own data model. To cope with this problem, the trend is now to work with a standard architecture allowing the integration of all environments to manage and the use of a common data model in order to provide a homogeneous view of management information.

The main issue with visualizing complex systems is how to represent the information in the most effective and aesthetic way in order to easily understand all events and resources and allow the user to control his/her tasks. Therefore, we think that proposing tools, which enable to customize the 3D visualization, will really improve the monitoring and management tasks because it is always easier to understand a system that can be well controlled. Other advantages of customizing the visualization are, firstly to enable monitoring any kind of system because the metaphors are not dedicated to a specific system, and secondly it allows several users to have different representations of the system and events according to their needs.

Computer network management and monitoring is a field where several works have been done. Almost all visualization techniques have been used to offer efficient tools in order to facilitate manager’s tasks but several efforts should be done in relation to the huge amount of dynamical information and the increasing number of nodes.

To deal with this problem, many traditional tools use 2D visualization techniques [Hew05] [Brad05] [Deb00]. 3D visualization techniques [Ben99] [Brow00] [Bmc05] have facilitated the understanding of a complex system by eliminating some restrictive issues of 2D techniques such as display clutter and device overlaps. The last generation of tools uses virtual reality techniques [Jam98] [Rus00] that facilitate the understanding of complex system, for example, by displaying 3D virtual rooms where many users represented by virtual humans cooperate in monitoring the entire system.

Whatever technique and algorithm are used, the huge amount of dynamical information will always be a major barrier for understanding a large and complex system. Our approach is not simply to allow visualizing an entire system but also only visualizing in 3D all necessary management information for monitoring tasks according to the events, which occurred. Therefore, the displayed information is only the one that is generated by the interesting events. As our main aim is to give the users the control of the system they monitor, this paper will focus on how to allow managers customizing the visualization according to their needs and their roles.

2. STANDARD INFORMATION MODEL REQUIREMENT

To deal with the variety of technology used in each managed device the DMTF (Distributed Management Task Force) proposes an object-oriented model, CIM (Common Information Model), aiming to provide a common way to represent the computing and networking elements and the relationships between them.

Information collection

Most tools for complex network management use SNMP agents running on each device to collect management information. However, the problem becomes very complex when the system to study is built with different environments each proposing its own management protocol. With the DMTF effort, it becomes possible to manage complex systems built with heterogeneous environments and applications (figure 1).

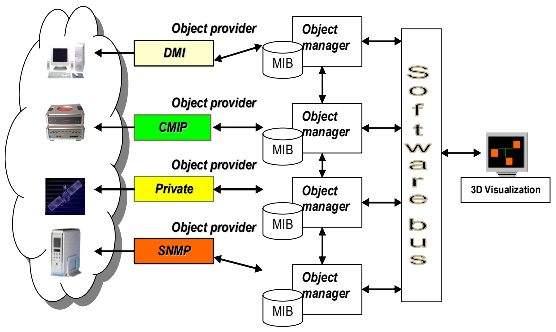

Figure 1: Collecting information process

To cope with such systems, the DMTF proposes the WBEM (Web-Based Enterprise Management) architecture [Wbe05] that introduces the notions of object manager (OM) and object provider (OP). An object provider is a management agent responsible with collecting management information and the integration of all specific environments (for example UNIX, SNMP, LDAP, etc). Once collected, the data is stored in a management information base (MIB) that characterizes an object manager. An object manager is an application responsible of one or several management domains (functional or structural). In such a system, the user sets up the list of interesting information via a query system. The list of queries is sent to the object managers responsible of the domain to study, which requests the appropriate manager agents (object providers). We are developing an interface that will allow user specifying graphically the queries.

Information model

In order to provide a common view of computing network elements and relationships, DMTF proposes an object-oriented model CIM [Cim05] for modeling the management information base. Through the CIM concept, DMTF proposes structural concepts derived from the object paradigm and new specific concepts (qualifier, trigger, indication) expressing constraints and/or meta-information on the structural concepts, and the dynamic of modeled elements.

Using those grammars, a modeling approach with three levels of abstraction is proposed. The “Core Model” introduces high-level abstract classes allowing the organization of the managed elements into physical and logical elements. The “Common Model” is the extension of the “Core Model” to the following domains: system, application, network, physical equipment and functional equipment; and the “Extension Model”: specializes the “Common Model” to the technology domains related to the implementation of the managed resources. Extension Models are defined by individual companies or organizations, but not by the DMTF.

3. VISUALIZATION

Visualization concept

If we want to monitor large-scale systems and particularly when the data exchanges between managed elements is very important for understanding the system, the most efficient way is to use relationship concepts. Indeed, this paradigm facilitates the process of human perception to understand the relational structures of information, thus the system structure. Therefore, our visualization concept consists in displaying in 3D all relevant information and their relationships necessary to understand an event occurring on the system in order to perform necessary actions.

Metaphors

Simplifying the understanding of a complex system first consists in allowing the identification of the main interest of the domain to study. For this, representing management information with metaphors having analogies with the real system largely improves the legibility of information and easily introduces the concept of the system to study. For our project, we have developed several metaphors that users can choose to represent a computer network. Default 3D forms represent devices automatically, such as computer, hub, server, switch, etc. If any of the simple 3D objects cannot relate visually to the information, it is also possible to add textures, to directly load a VRML object or to use simple 3D objects (cube, cylinder, etc). The size and color of relationships between the elements can change dynamically to indicate the system's behavior, for example bottlenecks, computer failures, etc.

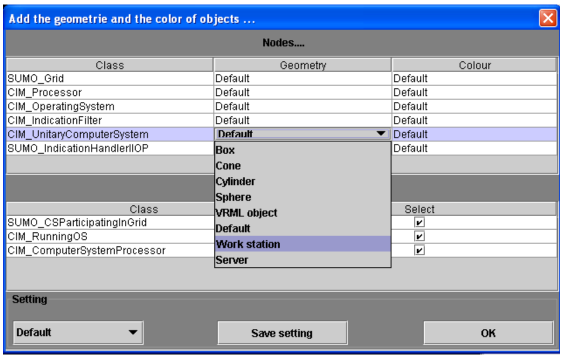

Figure 2: Choice of form and color of 3D objects

Another interesting feature of our tool is the possibility to save a configuration for each user in order to reload it the next time the tool is used (figure 2).

Information mapping

To deal with the huge amount of management information we have chosen the node-link paradigm to represent in 3D management information and their relationships in order to ease the understanding of the phenomenon to study. To avoid the display clutter we display only information about devices or elements concerned by event(s) to which the user subscribed. A partitioning algorithm is used to split the set of information in different groups so that only elements having no links to each other are in the same group. This algorithm has the same principle as the coloration algorithm graph presented in [Wal01].

Our mapping process begins with the choice of metaphors. The user can either customize the 3D representation of each class or let the system generate it automatically (figure 2). For each class, it is possible to choose simple 3D object such as a cube, a cylinder, a sphere or a cone as metaphor. After the choice of geometry, one can color each class so that all its instances are represented by a unique color. If the class colors are kept by default then the application will generate them automatically. One advantage to represent each class by different metaphor is the clarity of the display in order to distinguish easily each group of data. According to the user's needs, it is also possible to change graphically (figure 3) the metaphor of an object or of all the instances of its class.

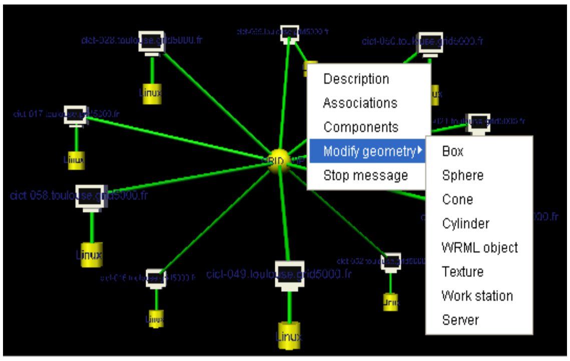

Figure 3: Graphical customizing of geometry of 3D objects

Figure 3 shows a 3D visualization of a cluster where 3D forms represent computer devices and yellow cylinders represent operating systems.

Navigation

Another factor raising the efficiency of visualization is the quality of navigation. Indeed it allows exploring the entire system and getting all details according to the user's needs. We have implemented several techniques to make users explore the system. The first way consists in zooming, in rotating and in translating the entire scene. By always using these mechanisms, it is possible to study independently a specific object. The main advantage of this ability is to rearrange the display in order to get the best presentation. Therefore, if there is a clutter or an overlapping, the user can always enhance the display.

A menu is associated with each object. It enables to get textual information about the clicked object such as its name, original class, its status (for example "down" or "running" for a device) and all other details present in the model. It is also possible to explore the visualization by displaying association or composition relationships between elements for a clicked object.

Event displaying

In order to detect easily all errors occurring in the system or any malfunctions we have implemented two kinds of metaphors. The first metaphor consists in displaying an alert message by modifying the color of the object where the problem is occurring. Therefore, the color of the object changes continuously (figure 4) from the original color to red until a necessary action is carried out.

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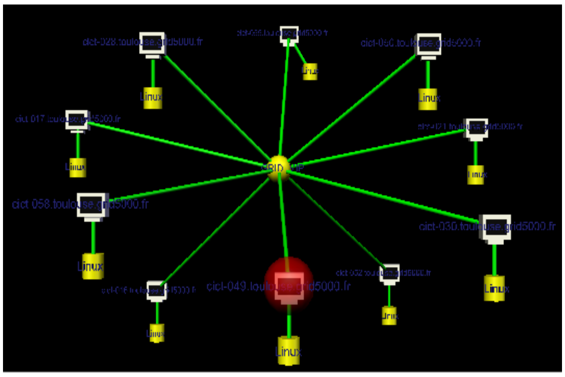

Figure 4: Event display

In the case of objects represented by VRML objects or other textured 3D shapes, a red torus is displayed which is continuously scaled up and down. The appearance of an event changes automatically the position of the source object on the screen in an unoccupied place. The second method is a 3D sound message associated with the color message in order to attract the user's attention and to easily identify the event source.

4. CONCLUSION AND FUTURE WORK

Our work is directed to the problem of management and monitoring of complex systems built with heterogeneous environments. We have found out that the relationship concept is the best way to understand the complex structure of a large system. In our system, each user can have its own configuration of the visualization and save it for the next use of the tool. We have also added a sound message coupled with color or shape changes in order to facilitate the identification of any malfunction in a system.

Our next goal is to integrate dynamic features in the visualization. For this, we will add an interface to allow users to specify the list of interesting events. We are also working on other metaphors and mechanisms in order to enable customizing the appearance of each event to survey.

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